Progress Report: Streaming readout for EIC detectors

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for the eRD23 EIC Streaming Readout Consortium

EIC R&D meeting, remote, March 2021

RBRC
RIKEN BNL Research Center

Stony Brook University

Who are we: SRC members

- ▶ **Brookhaven National Laboratory:** J. Huang, M. Purschke,
- ▶ **Catholic University of America:** S. Ali, V. Berdnikov, T. Horn, M. Muhoza, I. Pegg, R. Trotta
- ▶ **INFN Genova:** **M. Battaglieri,** M. Bondì, A. Celentano, L. Marsicano, P. Musico
- ▶ **INFN Roma:** F. Ameli
- ▶ **INFN Roma Tor Vergata:** A. d'Angelo, L. Lanza
- ▶ **INFN Bologna:** L. Cappelli, T. Chiarusi, F. Giacomini, C. Pellegrino
- ▶ **MIT:** D. Hasell, C. Fanelli, I. Friščić, R. Milner
- ▶ **Stony Brook University:** **J. C. Bernauer (also RBRC),** E. Cline
- ▶ **Thomas Jefferson National Accelerator Facility:** S. Boyarinov, C. Cuevas, M. Diefenthaler, R. Ent, Y. Furletova, V. Gyurjyan, G. Heyes, D. Lawrence, B. Raydo

Additionally many regulars

⟶We welcome new members!⟵

SRO VII Workshop

- November 16-18, 2020
- Organized by BNL
- All online because of COVID
- Many topics

For these reasons, we are studying and developing a full streaming-readout DAQ system for the EIC detector, integrating all the sub-detector components.

[YR started paradigm-agnostic. Organizers could not find anybody advocating for triggered readout.]

What we achieved: eRD23

- eRD23 had minimal funding levels. Concentrated on fostering community.
- Had 7 workshops, next one planned for April by MIT.
- Steadily growing attendance, including people not involved in EIC.
- Build community beyond the labs.

Results: Readout network

- ► Rate estimates (Jin Huang)
  - ► Baseline rate for this/similar detector concept below sPHENIX, doable now.
- ► Bottleneck is disk space, not network. Cost, not technology.
- ► Protocols
  - ► Essentially everybody has a packetized, content agnostic protocol
  - ► Easily extended for streaming
  - ► No show stoppers, but find optimal solution wrt. I/O

Results: timing & accelerator integration

- ▶ Phase-lock to bunch clock advantageous
    - ▶ Hardware at sPHENIX probably portable
    - ▶ Can also distribute start/stop/mark signals
- ▶ System must provide fast feed back to accelerator control
    - ▶ HW signals generated in FEE or concentrators
    - ▶ Software can provide soft-realtime info at higher level.
- ▶ Plan for staged bring-up

Results: FEE

- ▶ Collected info on possible readout ASICs
- ▶ Connection with industry. What is in the pipeline
- ▶ Must be a topic during technology down-select. Can you read out your detector! Can you pay for it?
  - ▶ Trade-off between performance, size, price. One don't always get to pick two.

Results: Software

- No complete online event building necessary.
  - Do subset for QA
- Border between online and offline blurs.
  - Have at least some capabilities of offline analysis online
- Border between counting room, on-site and off-site compute blurs
  - Need flexible framework

Progress outside of eRD23: JLAB

- ▶ FADC250 in streaming mode
- ▶ TriDas back end software
- ▶ JANA2 analysis software
- ▶ INDRA-ASTRA lab: ML/AI anomaly detection
- ▶ CLAS 12 SRO test →ERSAP will redesign backend in general/EIC compatible way

Progress outside of eRD23: BNL (sPHENIX)

- ► Final hardware and computing infrastructure installed. Enough for streaming tests up to 18Tbps!
- ► Updated Timing modules based on Xilinx Ultrascale+

- ▶ Development of streaming TDC (UGrad project).
- ▶ Bit-level Protocol generator/tool generation/documentation system

The way ahead: Exp's with SRO

- ► JLAB: Continued development of SRO for CLAS12, Hall-D
- ► BNL: sPHENIX hybrid readout. EIC-scale rates
  - ► Already pays off: *The PAC commends sPHENIX for developing the continuous streaming readout option that will increase their data collection in Run-24 by orders of magnitude.*
- ► MIT/SBU/INFN/CUA: Beam tests for TPEX at DESY and JLAB planned

This will provide useful hands-on experience in the next few years

SRO for EIC: what is "same-old same-old"

- ▶ Update rate estimates for different detectors
- ▶ Software framework/toolkit
- ▶ Read-out network
- ▶ Play-back tools/analysis
- ▶ Data flow management on-site

SRO for EIC: What is new, but not "just work"

- Data flow management off-site
- Online, high-level data processing
  - for QA (definitely) and data reduction (if needed)
  - orchestration with HPC
- ML/AI integration
- Existing ASICs: Are process nodes still available?
  - Likely yes
  - But maybe needs rework for masks etc (see SAMPA)

SRO for EIC: Critical items

- Can we get more physics with SRO?
- Do we have a readout solution for all detectors? (Not limited to SRO)
  - Rate manageable?
  - Heat/Power/...?
- Do we need new ASICs?
  - Timeline is CRITICAL: 6 years after funding minimum for new design. So 2028!
- Detector readout cannot be an afterthought.
  - Need to be part of proposal process!
  - Must span sub-detectors

Our plans for the future

- ► Continue workshop series – important for community
- ► Work closely with proposal groups
  - ► ECCE, IP6, others?
  - ► Reach out to us if nobody of us is part of your proposal!
  - ► Come to the workshop(s)!
- ► EOIs:
  - ► 18/45 mention streaming readout
  - ► 5/45 metion trigger electronics (mostly "have experience with")
  - ► 13/45 mention some form of electronics

Future activities

Work items:

- Work on proposal/with detector groups to integrate (S)RO in the detector design.
- Develop full readout framework
  - FEE/ RO Network/ Software
- Validation of SRO (sPHENIX, CLAS12), EIC specific components

Most work so far funded by / in context of other projects. No resources to do EIC specific work.
This is not sustainable. A dedicated EIC solution (SRO or triggered) needs dedicated financial support.

- Need commitment, resources.
- Cannot be "distributed" over detector development.
- Cannot be postponed.